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AS-MAGNESIUM PRESSURE ~~DIE-CAST ALLOY~~ AND METHOD FOR ~~PRODUCING~~ A SUBASSEMBLY ~~PART FROM AN AS-MAGNESIUM PRESSURE DIE-CAST ALL~~OY OF THIS TYPE

[0001] The present invention relates to an AS die casting alloy, in particular for automotive components susceptible to thermal stress.

[0002] If magnesium alloys are used in components susceptible to high thermal stresses, they must have a low aluminum content to be creep-resistant, so that when the unit operates at a high temperature, the connecting screws do not come loose. MgAl2Si1 die casting alloys, also known as AS21 alloys and MgAl4Si1 alloys, also known as AS41 alloys, are known to be creep-resistant alloys. With decreasing aluminum content in the magnesium alloy, fewer $Mg_{17}Al_{12}$ grain boundary separations, susceptible to creep, occur under thermal stress at temperatures over 120°C; therefore, AS21 alloys are more creep-resistant than AS41 alloys. Due to its lower aluminum content, an AS21 alloy, however, has a lower strength, is more susceptible to corrosion, and, mainly, is difficult to cast. Casting errors such as adhesion to the casting mold and hot cracks do not allow large components to be reliably mass produced.

[0003] An AS41 alloy, however, does not have these disadvantages. It is, however, more susceptible to creep and less ductile due to the high $Mg_{17}Al_{12}$ grain boundary separations. A lower toughness reduces the dynamic strength of the alloy in the case of the notch effect, caused, for example, by stone impact, corrosion, etc. In the case of a thermal load, ductility drops as a result of the separation of additional, brittle $Mg_{17}Al_{12}$ phases at the grain boundaries. Therefore, the allowable dynamic load on components made of AS41 alloys decreases during drive operation. WO A-01 02 614 describes alloys of this type.

[0004] The object of the present invention is therefore to provide an AS alloy which is thermally stable regarding creep and ductility, while being satisfactorily castable.

[0005] This object is achieved according to the present invention by an AS die casting alloy of the type recited in the preamble by the fact that its aluminum content is between the aluminum content of AS21 and AS41 alloys.

[0006] According to the present invention, a metallurgical compromise has been found between castability, strength, and corrosion resistance on the one hand, which are achieved by a higher aluminum content, and creep-resistance and ductility on the other hand, which are achieved by a lower aluminum content. In the AS die casting alloy according to the present invention, the aluminum content is between those of the standard alloys AS21 and AS41.

[0007] Casting tests on transmission housings have shown that AS alloys above an aluminum content of 2.5 wt.% are easily cast. No adhesion of castings to the die casting mold was found. In addition, the castings exhibited no hot cracks. Furthermore, a higher aluminum content compared to an AS21 alloy results in the desired increase in strength. Because the aluminum content of the AS die casting alloy according to the present invention does not reach that of an AS41 alloy, there is no danger of the die cast part to embrittle.

[0008] According to the present invention, the aluminum content is between 2.5 wt.% and 4 wt.%, in particular between 2.8 wt.% and 3.5 wt.%, preferably 3 wt.%. Castability, strength, corrosion-resistance, creep-resistance, and ductility may be adjusted within certain limits by selecting the aluminum content.

[0009] According to the present invention, the AS die casting alloy is an MgAl3Si1 alloy (AS31). This alloy has an aluminum content and in particular additional alloy components which are between those of AS21 and AS41 alloys.

[0010] In particular, the AS die casting alloy according to the present invention has an Mn content which is greater than 0.20 wt.%. The Cu content is < 100 ppm. The Ni content is < 20 ppm. The Fe content is also < 50 ppm. The Si content is between 0.7 wt.% and 1.5 wt.%. In addition, the Zn content is less than 0.20 wt.%.

[0011] Finally, a relatively high amount of Al is dissolved in the Mg matrix. This results in high ductility, which is described in more detail below. This is achieved in particular by water quenching the AS die casting alloy according to the present invention.

[0012] The above object is furthermore achieved in a method for manufacturing a thermally stressable component made of the AS die casting alloy recited in the preamble by water quenching after casting or after the casting mold is opened.

[0013] As mentioned above, high ductility is hereby achieved. Compared to slow cooling in air, more aluminum is dissolved in the Mg matrix in the case of water quenching, so that a favorable mixed crystal hardening occurs, which, contrary to $Mg_{17}Al_{12}$ separation hardening, barely embrittles the microstructure. Furthermore, contrary to air cooling according to the related art, the aluminum which is not dissolved in the Mg matrix separates in the form of very fine $Mg_{17}Al_{12}$ phases.

[0014] Also, in the case of water quenching, separation occurs not only at the grain boundaries, but also in the Mg matrix. The tensile strength and the permanent elongation limit of the AS die casting alloy according to the present invention are thereby considerably increased in comparison to air cooling, without the elevated Al content compared to the known AS21 alloy causing deterioration in toughness, because only a small amount of coarse $Mg_{17}Al_{12}$ grain boundary phases appear.

[0015] Finally, thermal stability of the microstructure in the case of long-term stress at 150°C is noticeably improved. In the case of air cooling according to the related art, the separated coarse $Mg_{17}Al_{12}$ grain boundary separations function as nuclei for forming further $Mg_{17}Al_{12}$ phases, so that after thermal aging the grain boundaries are fully occupied, i.e., anchored with $Mg_{17}Al_{12}$ phases. This results in total material embrittlement.

[0016] When water quenching is used according to the present invention, the new AS die casting alloy has fewer and finer $Mg_{17}Al_{12}$ grain boundary separations and thus fewer nuclei, so that the grain boundaries barely embrittle upon thermal aging.

[0017] The water-quenched AS31 die casting according to the present invention suffers only a slight loss of elongation at rupture after thermal aging for 2000 hours at 150°C, although the tensile strength and the permanent elongation limit advantageously increase due to the separation of further fine $Mg_{17}Al_{12}$ phases. This results in excellent dynamic strength properties overall, even in the case of thermal stress at 150°C.

[0018] The creep resistance of the alloy according to the present invention is improved due to water quenching. Thus, as mentioned before, more aluminum is dissolved in the Mg matrix from the beginning. This improves creep resistance to the point where the loosening tendency of aluminum screws corresponds to that of the known AS21 alloy despite the higher Al content of the alloy according to the present invention.

[0019] It has been found that, for a water-quenched AS41 alloy, the relaxation properties of Al screws at 150°C are poorer than for the AS31 alloy according to the present invention. The reason therefor is the higher aluminum content in the AS41 alloy, i.e., the higher proportion of non-creep resistant $Mg_{17}Al_{12}$ grain boundary phases in the original microstructure.

[0020] The AS31 alloy according to the present invention, in particular a transmission housing manufactured therefrom, has a minimum tensile strength of 180 MPa, a minimum permanent elongation limit of 110 MPa, and the minimum elongation at rupture in the area of the casting notch is 6%.

[0021] The component manufactured from the alloy according to the present invention is preferably water quenched within 60 s, in particular within 40 s, preferably within 30 s after casting or after the die casting mold is opened. This temperature drop immediately after

casting prevents, as mentioned above, the formation of an excessive amount of coarse $Mg_{17}Al_{12}$ grain boundary phases.